

CHEMISTRY

9701/11

Paper 1 Multiple Choice

October/November 2014

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

* 6 1 4 0 2 2 2 5 3 7 *



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Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

DO NOT WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

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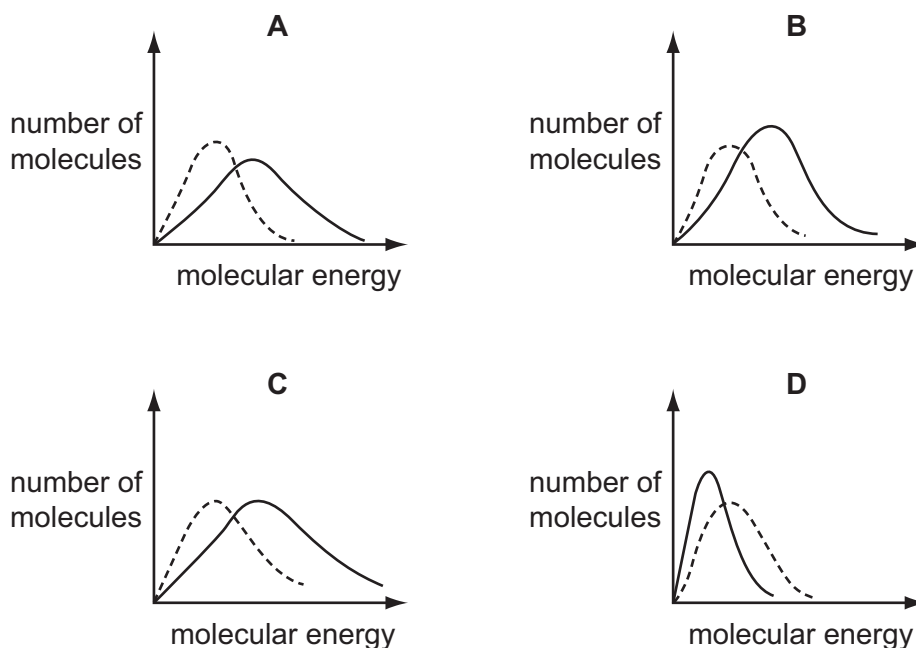
This document consists of **13** printed pages and **3** blank pages.



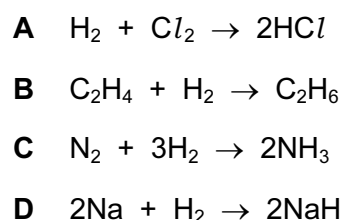
Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 Which solid-line curve most accurately represents the distribution of molecular energies in a gas at 500 K if the dotted-line curve represents the corresponding distribution for the same gas at 300 K?



- 2 In which reaction does hydrogen behave as an oxidising agent?



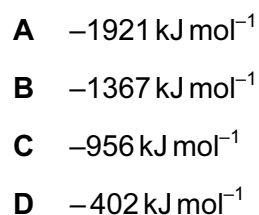
- 3 Ethanol is increasingly being used as a fuel for cars.

The standard enthalpy change of formation of carbon dioxide is -393 kJ mol^{-1} .

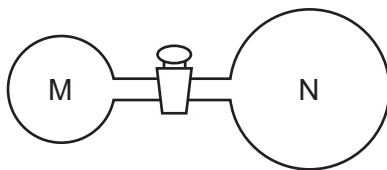
The standard enthalpy change of formation of water is -286 kJ mol^{-1} .

The standard enthalpy change of formation of ethanol is -277 kJ mol^{-1} .

What is the standard enthalpy change of combustion of ethanol?



- 4 Two glass vessels M and N are connected by a closed valve.



M contains helium at 20°C at a pressure of $1 \times 10^5 \text{ Pa}$. N has been evacuated, and has three times the volume of M. In an experiment, the valve is opened and the temperature of the whole apparatus is raised to 100°C .

What is the final pressure in the system?

- A $3.18 \times 10^4 \text{ Pa}$
 B $4.24 \times 10^4 \text{ Pa}$
 C $1.25 \times 10^5 \text{ Pa}$
 D $5.09 \times 10^5 \text{ Pa}$
- 5 The table shows the physical properties of four substances.

Which substance could be hydrogen chloride?

	melting point $/^{\circ}\text{C}$	electrical conductivity of solid	electrical conductivity of liquid	electrical conductivity of aqueous solution
A	-119	poor	poor	insoluble
B	-115	poor	poor	good
C	-50	poor	poor	poor
D	993	poor	good	good

- 6 Aluminium carbide, Al_4C_3 , reacts readily with aqueous sodium hydroxide. The two products of the reaction are NaAlO_2 and a hydrocarbon. Water molecules are also involved as reactants.

What is the formula of the hydrocarbon?

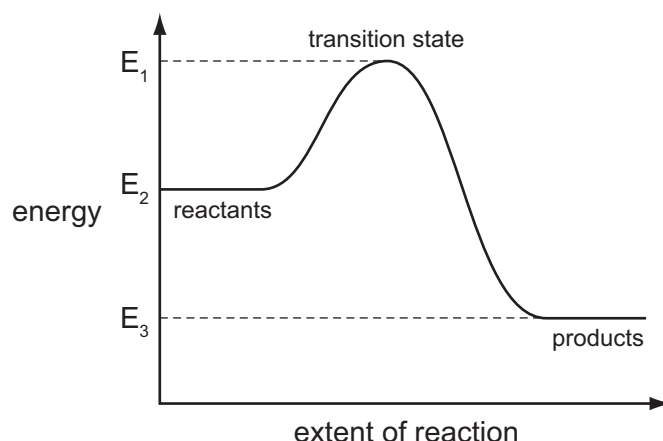
- A CH_4 B C_2H_6 C C_3H_8 D C_6H_{12}

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- A $-1410 \text{ kJ mol}^{-1}$
 B -769 kJ mol^{-1}
 C $-30.7 \text{ kJ mol}^{-1}$
 D $-16.7 \text{ kJ mol}^{-1}$
- 8 The reaction pathway diagram below illustrates the energies of the reactants, the products and the transition state of a reaction.



Which expression represents the activation energy of the forward reaction?

- A $E_1 - E_2$ B $E_2 - E_1$ C $E_2 - E_3$ D $E_3 - E_2$
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Which statement explains why the boiling point of methylpropan-1-ol is lower than that of butan-1-ol?

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 B Methylpropan-1-ol has weaker covalent bonds than butan-1-ol.
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- 10 Which row correctly describes the electrodes used in the electrolysis cell for the production of aluminium?

	anode	cathode
A	carbon	carbon
B	carbon	steel
C	steel	carbon
D	steel	steel

- 11 For which equation is the enthalpy change correctly described as an enthalpy change of formation?

- A** $\text{C(g)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$
B $\text{C(s)} + \frac{1}{2} \text{O}_2\text{(g)} \rightarrow \text{CO(g)}$
C $2\text{N(g)} + 4\text{O(g)} \rightarrow \text{N}_2\text{O}_4\text{(g)}$
D $2\text{NO(g)} + \text{O}_2\text{(g)} \rightarrow 2\text{NO}_2\text{(g)}$

- 12 Element **X**, in Period 3, has the following properties.

- Its oxide has a giant structure.
- It forms covalent bonds with chlorine.
- Its oxide will neutralise HCl(aq) .

What is element **X**?

- A** Mg **B** Al **C** Si **D** P

- 13 Which property is **not** associated with the element sodium?

- A** It can react with cold water to form hydrogen.
B It forms a basic oxide.
C It forms a neutral chloride.
D It is an oxidising agent.

14 Use of the Data Booklet is relevant to this question.

Sir Humphrey Davy discovered boron, calcium, magnesium and sodium.

Which of these elements has the **second** smallest atomic radius in its group and the **third** lowest first ionisation energy in its period?

- A boron
- B calcium
- C magnesium
- D sodium

15 Use of the Data Booklet is relevant to this question.

A sample of potassium oxide, K_2O , is dissolved in 250 cm^3 of distilled water. 25.0 cm^3 of this solution is titrated against sulfuric acid of concentration 2.00 mol dm^{-3} . 15.0 cm^3 of this sulfuric acid is needed for complete neutralisation.

Which mass of potassium oxide was originally dissolved in 250 cm^3 of distilled water?

- A 2.83 g B 28.3 g C 47.1 g D 56.6 g

16 Chlorine gas reacts with cold aqueous sodium hydroxide. It can also react with hot aqueous sodium hydroxide.

What are the oxidation numbers of chlorine in the products of these reactions?

	cold aqueous sodium hydroxide	hot aqueous sodium hydroxide
A	-1, +1	-1, +5
B	-1, +1	+1, +6
C	-1, +2	-1, +5
D	-1, +2	+1, +6

17 Under standard conditions, which statement is correct?

- A $Cl^-(aq)$ can oxidise $Br_2(aq)$.
- B $Cl^-(aq)$ can reduce $Br_2(aq)$.
- C $Cl_2(aq)$ can oxidise $Br^-(aq)$.
- D $Cl_2(aq)$ can reduce $Br^-(aq)$.

- 18 Total removal of the pollutant sulfur dioxide, SO_2 , is difficult. The quantities emitted from furnace chimneys can be lowered by using desulfurisation plants. The gases are reacted with calcium hydroxide to remove the SO_2 .

What is the main product formed **initially**?

- A $\text{Ca}(\text{HSO}_4)_2$ B CaS C CaSO_3 D CaSO_4

- 19 Which oxide does **not** react with cold dilute sodium hydroxide to produce a salt?

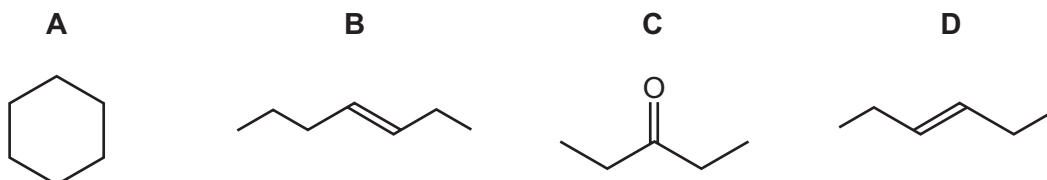
- A Al_2O_3 B P_4O_{10} C SO_2 D SiO_2

- 20 Which row correctly describes the reaction between propene and bromine, $\text{Br}_2(\text{l})$?

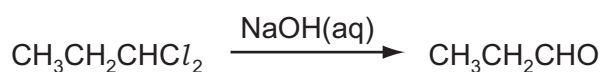
	reaction mechanism	organic product
A	electrophilic addition	$\text{CH}_3\text{CHBrCH}_2\text{Br}$
B	electrophilic addition	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$
C	nucleophilic substitution	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$
D	nucleophilic substitution	$\text{CH}_3\text{CHBrCH}_2\text{Br}$

- 21 Use of the Data Booklet is relevant to this question.

Which compound has an M_r of 84 and will react with HBr to give a product with an M_r of 164.9?



- 22 1,1-dichloropropane reacts with aqueous sodium hydroxide in a series of steps to give propanal.



Which term describes the first step of this reaction?

- A addition
B elimination
C oxidation
D substitution

- 23 Considering **only** structural isomers, what is the number of alcohols of each type with the formula $C_5H_{12}O$?

	primary	secondary	tertiary
A	3	3	2
B	4	2	2
C	4	3	1
D	5	2	1

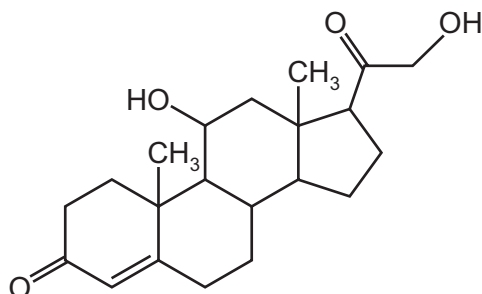
- 24 Lactic acid, $CH_3CH(OH)CO_2H$, causes pain when it builds up in muscles.

Which reagent reacts with **both** of the $-OH$ groups in lactic acid?

- A** acidified potassium dichromate(VI)
B ethanol
C sodium
D sodium hydroxide
- 25 In the hydrolysis of bromoethane by aqueous sodium hydroxide, what is the nature of the attacking group and of the leaving group?

	attacking group	leaving group
A	electrophile	electrophile
B	electrophile	nucleophile
C	nucleophile	electrophile
D	nucleophile	nucleophile

- 26 Corticosterone is a hormone involved in the metabolism of carbohydrates and proteins.



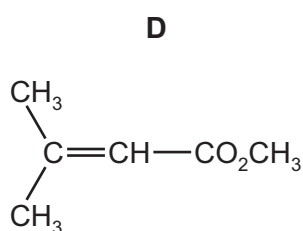
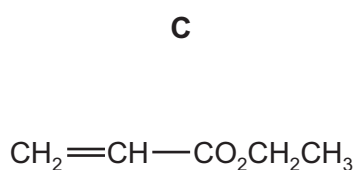
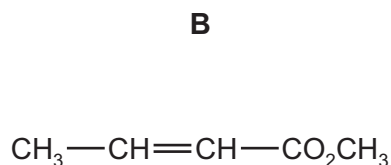
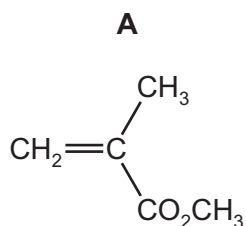
corticosterone

How many chiral centres are there in one molecule of corticosterone?

- A** 5 **B** 6 **C** 7 **D** 8

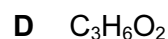
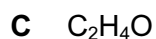
27 Methyl methylpropenoate is the monomer used to make *Perspex*.

Which diagram correctly shows methyl methylpropenoate?

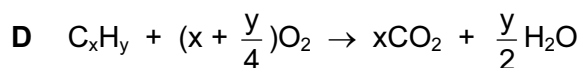
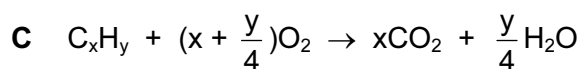
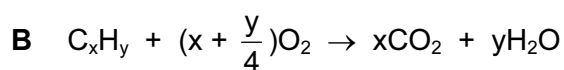
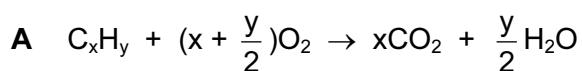


28 The ester $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_3$ is responsible for the aroma of apples.

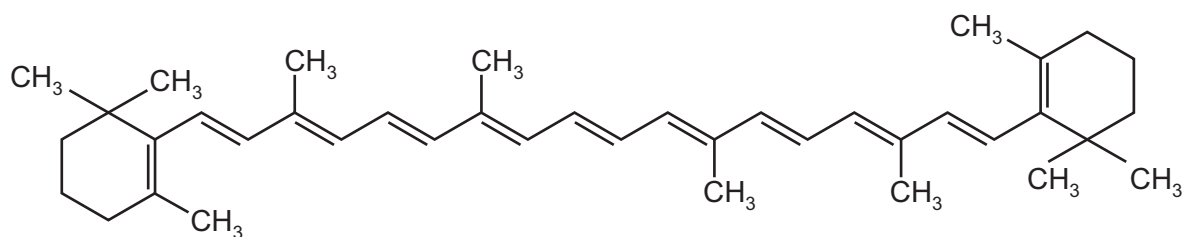
When this ester is hydrolysed by acid in the stomach, what is the empirical formula of the organic acid produced?



29 Which equation correctly represents the balanced equation for the complete combustion of a hydrocarbon with the formula C_xH_y ?



30 β -carotene is responsible for the orange colour of carrots.



β -carotene

β -carotene is oxidised by hot, concentrated, acidified KMnO_4 .

When an individual molecule of β -carotene is oxidised in this way, many product molecules are formed.

How many of these product molecules contain a ketone functional group?

- A** 4 **B** 6 **C** 9 **D** 11

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

31 *Use of the Data Booklet is relevant to this question.*

Which ions contain one or more unpaired electrons?

- 1** Cu^{2+}
- 2** Mn^{3+}
- 3** V^{3+}

32 *Use of the Data Booklet is relevant to this question.*

The bond energy of the Br–O bond is 235 kJ mol^{-1} .

Which reactions are exothermic?

- 1** $\text{OH}\cdot + \text{HBr} \rightarrow \text{H}_2 + \text{BrO}\cdot$
- 2** $\text{OH}\cdot + \text{HBr} \rightarrow \text{H}_2\text{O} + \text{Br}\cdot$
- 3** $\text{H}\cdot + \text{HBr} \rightarrow \text{H}_2 + \text{Br}\cdot$

33 A reversible reaction is catalysed.

Which statements about the effects of the catalyst on this system are correct?

- 1** The catalyst alters the mechanism of the reaction.
- 2** The catalyst reduces the activation energy for both the forward and the backward reaction.
- 3** The catalyst alters the composition of the equilibrium mixture.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

- 34** A student borrowed a friend's chemistry notes and copied out the notes in the box below.

Which statements are correct?

A gas behaves **less** like an ideal gas when the gas

- 1** is at low pressure.
- 2** is at low temperature.
- 3** can be easily liquefied.

- 35** On being heated, hydrogen iodide breaks down more quickly than hydrogen chloride.

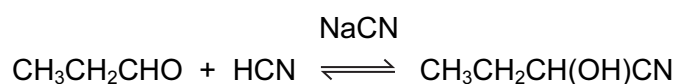
Which statements explain this faster rate?

- 1** The HI bond is weaker than the HCl bond.
- 2** The reaction of the breakdown of HI has a smaller activation energy than that of HCl.
- 3** The breakdown of HI is more exothermic than that of HCl.

- 36** Which statements about calcium oxide are correct?

- 1** It reacts with cold water.
- 2** It is produced when calcium nitrate is heated.
- 3** It can be reduced by heating with magnesium.

- 37** Propanal will react with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.



Which statements about the reaction of propanal with hydrogen cyanide are correct?

- 1** The CN^- ion attacks the propanal molecule to form an intermediate ion.
- 2** The product of the reaction has a chiral carbon atom.
- 3** The CN^- ion is a stronger electrophile than the HCN molecule.

- 38 **X** is an organic compound that gives a precipitate with aqueous silver nitrate. This precipitate remains undissolved when concentrated aqueous ammonia is added.

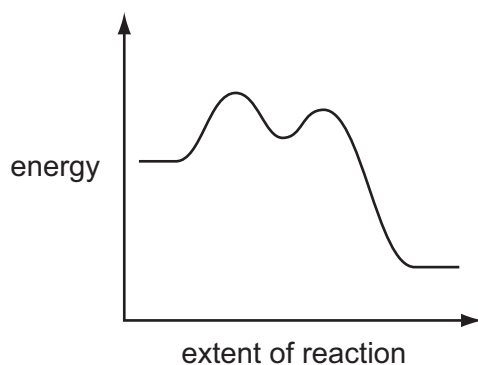
What is a possible identity for **X**?

- 1 iodomethane
- 2 2-bromobutane
- 3 2-chlorobutane

- 39 For which mixtures of reagents are the colour changes described correctly?

	reagents	colour change
1	pentanal + hot, acidified potassium dichromate(VI)	orange to green
2	pentan-2-one + warm Fehling's reagent	no change
3	cyclohexane + cold, acidified potassium manganate(VII)	purple to colourless

- 40 A reaction pathway diagram is shown.



Which reactions would have this profile?

- 1 $(\text{CH}_3)_3\text{CBr} + \text{NaOH} \rightarrow (\text{CH}_3)_3\text{COH} + \text{NaBr}$
- 2 $\text{CH}_3\text{CH}_2\text{Br} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{NaBr}$
- 3 $(\text{CH}_3)_3\text{CCH}_2\text{CH}_2\text{Cl} + 2\text{NH}_3 \rightarrow (\text{CH}_3)_3\text{CCH}_2\text{CH}_2\text{NH}_2 + \text{NH}_4\text{Cl}$

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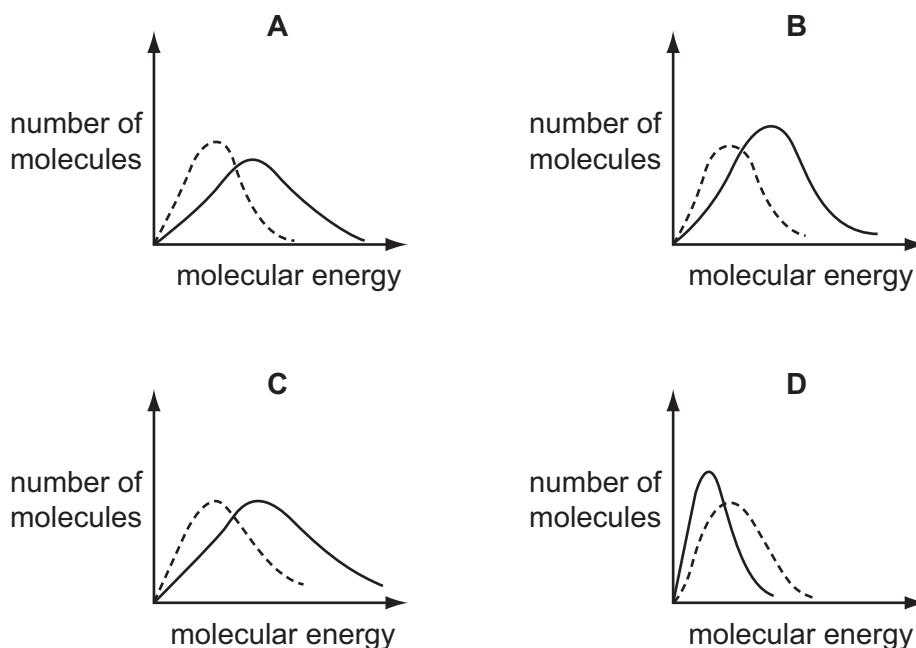
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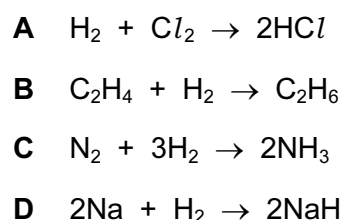
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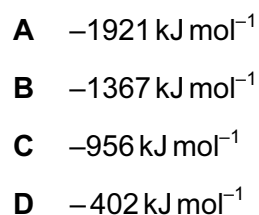
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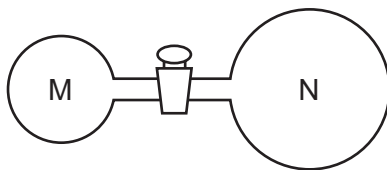
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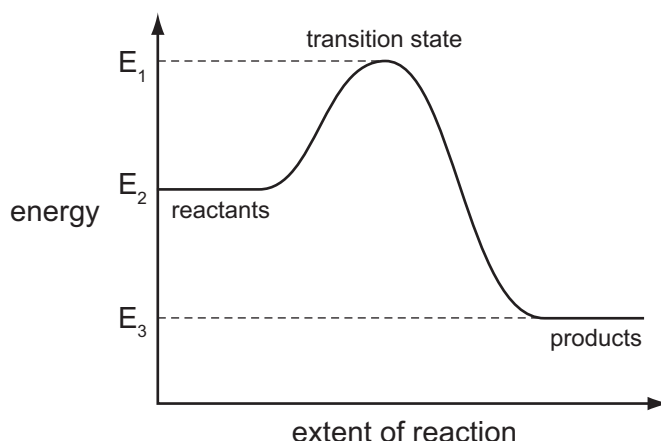
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C It forms a neutral chloride.
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Sir Humphrey Davy discovered boron, calcium, magnesium and sodium.

Which of these elements has the **second** smallest atomic radius in its group and the **third** lowest first ionisation energy in its period?

- A boron
- B calcium
- C magnesium
- D sodium

15 Use of the Data Booklet is relevant to this question.

A sample of potassium oxide, K_2O , is dissolved in 250 cm^3 of distilled water. 25.0 cm^3 of this solution is titrated against sulfuric acid of concentration 2.00 mol dm^{-3} . 15.0 cm^3 of this sulfuric acid is needed for complete neutralisation.

Which mass of potassium oxide was originally dissolved in 250 cm^3 of distilled water?

- A 2.83 g B 28.3 g C 47.1 g D 56.6 g

16 Chlorine gas reacts with cold aqueous sodium hydroxide. It can also react with hot aqueous sodium hydroxide.

What are the oxidation numbers of chlorine in the products of these reactions?

	cold aqueous sodium hydroxide	hot aqueous sodium hydroxide
A	-1, +1	-1, +5
B	-1, +1	+1, +6
C	-1, +2	-1, +5
D	-1, +2	+1, +6

17 Under standard conditions, which statement is correct?

- A $Cl^-(aq)$ can oxidise $Br_2(aq)$.
- B $Cl^-(aq)$ can reduce $Br_2(aq)$.
- C $Cl_2(aq)$ can oxidise $Br^-(aq)$.
- D $Cl_2(aq)$ can reduce $Br^-(aq)$.

- 18 Total removal of the pollutant sulfur dioxide, SO_2 , is difficult. The quantities emitted from furnace chimneys can be lowered by using desulfurisation plants. The gases are reacted with calcium hydroxide to remove the SO_2 .

What is the main product formed **initially**?

- A $\text{Ca}(\text{HSO}_4)_2$ B CaS C CaSO_3 D CaSO_4

- 19 Which oxide does **not** react with cold dilute sodium hydroxide to produce a salt?

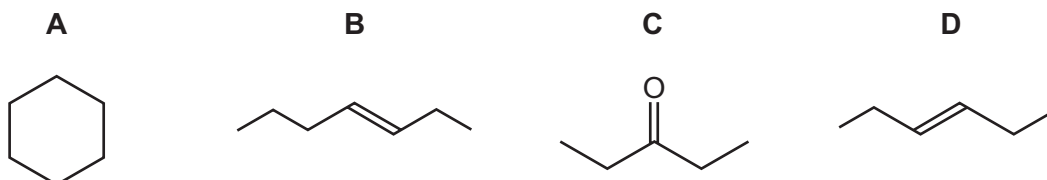
- A Al_2O_3 B P_4O_{10} C SO_2 D SiO_2

- 20 Which row correctly describes the reaction between propene and bromine, $\text{Br}_2(\text{l})$?

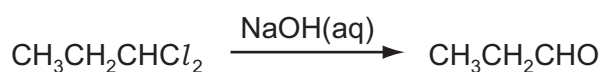
	reaction mechanism	organic product
A	electrophilic addition	$\text{CH}_3\text{CHBrCH}_2\text{Br}$
B	electrophilic addition	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$
C	nucleophilic substitution	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$
D	nucleophilic substitution	$\text{CH}_3\text{CHBrCH}_2\text{Br}$

- 21 Use of the Data Booklet is relevant to this question.

Which compound has an M_r of 84 and will react with HBr to give a product with an M_r of 164.9?



- 22 1,1-dichloropropane reacts with aqueous sodium hydroxide in a series of steps to give propanal.



Which term describes the first step of this reaction?

- A addition
B elimination
C oxidation
D substitution

- 23 Considering **only** structural isomers, what is the number of alcohols of each type with the formula $C_5H_{12}O$?

	primary	secondary	tertiary
A	3	3	2
B	4	2	2
C	4	3	1
D	5	2	1

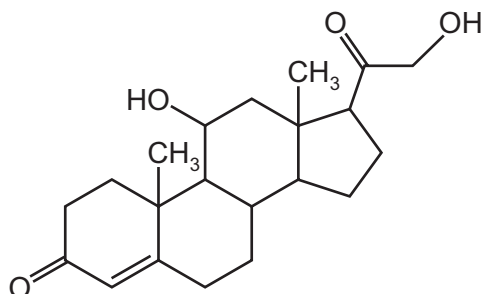
- 24 Lactic acid, $CH_3CH(OH)CO_2H$, causes pain when it builds up in muscles.

Which reagent reacts with **both** of the $-OH$ groups in lactic acid?

- A** acidified potassium dichromate(VI)
B ethanol
C sodium
D sodium hydroxide
- 25 In the hydrolysis of bromoethane by aqueous sodium hydroxide, what is the nature of the attacking group and of the leaving group?

	attacking group	leaving group
A	electrophile	electrophile
B	electrophile	nucleophile
C	nucleophile	electrophile
D	nucleophile	nucleophile

- 26 Corticosterone is a hormone involved in the metabolism of carbohydrates and proteins.



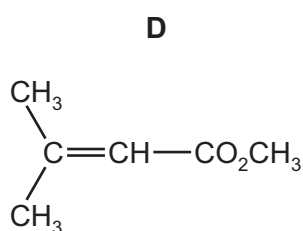
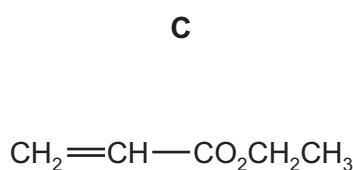
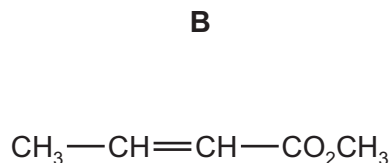
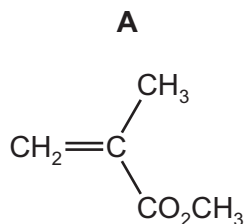
corticosterone

How many chiral centres are there in one molecule of corticosterone?

- A** 5 **B** 6 **C** 7 **D** 8

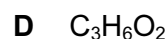
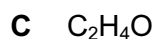
27 Methyl methylpropenoate is the monomer used to make *Perspex*.

Which diagram correctly shows methyl methylpropenoate?

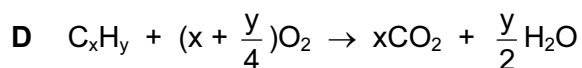
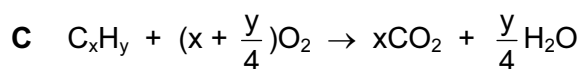
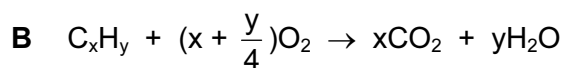
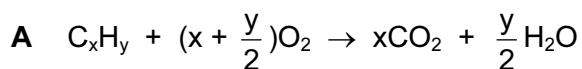


28 The ester $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_3$ is responsible for the aroma of apples.

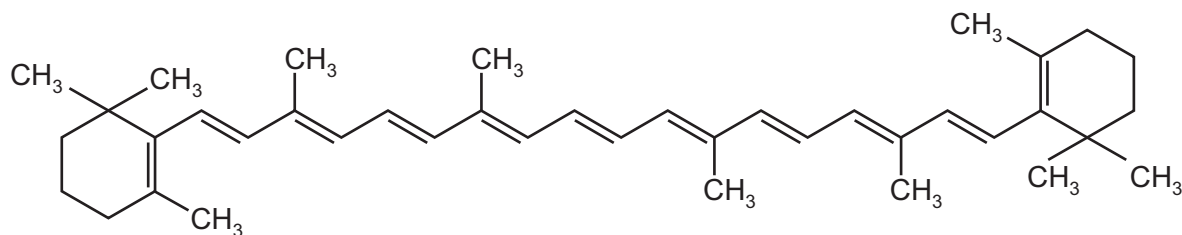
When this ester is hydrolysed by acid in the stomach, what is the empirical formula of the organic acid produced?



29 Which equation correctly represents the balanced equation for the complete combustion of a hydrocarbon with the formula C_xH_y ?



30 β -carotene is responsible for the orange colour of carrots.



β -carotene

β -carotene is oxidised by hot, concentrated, acidified KMnO_4 .

When an individual molecule of β -carotene is oxidised in this way, many product molecules are formed.

How many of these product molecules contain a ketone functional group?

- A** 4 **B** 6 **C** 9 **D** 11

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

31 *Use of the Data Booklet is relevant to this question.*

Which ions contain one or more unpaired electrons?

- 1** Cu^{2+}
- 2** Mn^{3+}
- 3** V^{3+}

32 *Use of the Data Booklet is relevant to this question.*

The bond energy of the Br–O bond is 235 kJ mol^{-1} .

Which reactions are exothermic?

- 1** $\text{OH}\cdot + \text{HBr} \rightarrow \text{H}_2 + \text{BrO}\cdot$
- 2** $\text{OH}\cdot + \text{HBr} \rightarrow \text{H}_2\text{O} + \text{Br}\cdot$
- 3** $\text{H}\cdot + \text{HBr} \rightarrow \text{H}_2 + \text{Br}\cdot$

33 A reversible reaction is catalysed.

Which statements about the effects of the catalyst on this system are correct?

- 1** The catalyst alters the mechanism of the reaction.
- 2** The catalyst reduces the activation energy for both the forward and the backward reaction.
- 3** The catalyst alters the composition of the equilibrium mixture.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

- 34** A student borrowed a friend's chemistry notes and copied out the notes in the box below.

Which statements are correct?

A gas behaves **less** like an ideal gas when the gas

- 1** is at low pressure.
- 2** is at low temperature.
- 3** can be easily liquefied.

- 35** On being heated, hydrogen iodide breaks down more quickly than hydrogen chloride.

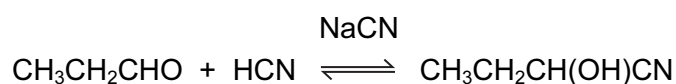
Which statements explain this faster rate?

- 1** The HI bond is weaker than the HCl bond.
- 2** The reaction of the breakdown of HI has a smaller activation energy than that of HCl.
- 3** The breakdown of HI is more exothermic than that of HCl.

- 36** Which statements about calcium oxide are correct?

- 1** It reacts with cold water.
- 2** It is produced when calcium nitrate is heated.
- 3** It can be reduced by heating with magnesium.

- 37** Propanal will react with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.



Which statements about the reaction of propanal with hydrogen cyanide are correct?

- 1** The CN^- ion attacks the propanal molecule to form an intermediate ion.
- 2** The product of the reaction has a chiral carbon atom.
- 3** The CN^- ion is a stronger electrophile than the HCN molecule.

- 38 **X** is an organic compound that gives a precipitate with aqueous silver nitrate. This precipitate remains undissolved when concentrated aqueous ammonia is added.

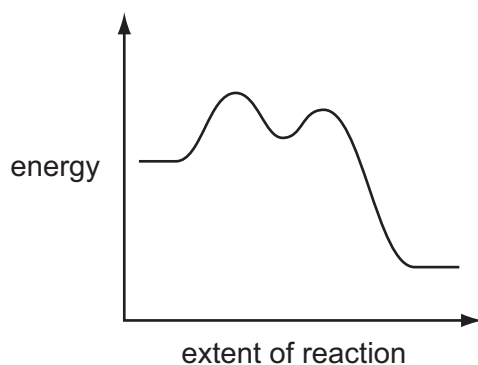
What is a possible identity for **X**?

- 1 iodomethane
- 2 2-bromobutane
- 3 2-chlorobutane

- 39 For which mixtures of reagents are the colour changes described correctly?

	reagents	colour change
1	pentanal + hot, acidified potassium dichromate(VI)	orange to green
2	pentan-2-one + warm Fehling's reagent	no change
3	cyclohexane + cold, acidified potassium manganate(VII)	purple to colourless

- 40 A reaction pathway diagram is shown.



Which reactions would have this profile?

- 1 $(\text{CH}_3)_3\text{CBr} + \text{NaOH} \rightarrow (\text{CH}_3)_3\text{COH} + \text{NaBr}$
- 2 $\text{CH}_3\text{CH}_2\text{Br} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{NaBr}$
- 3 $(\text{CH}_3)_3\text{CCH}_2\text{CH}_2\text{Cl} + 2\text{NH}_3 \rightarrow (\text{CH}_3)_3\text{CCH}_2\text{CH}_2\text{NH}_2 + \text{NH}_4\text{Cl}$

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CHEMISTRY

9701/13

Paper 1 Multiple Choice

October/November 2014

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

DO NOT WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

Electronic calculators may be used.

This document consists of **15** printed pages and **1** blank page.

Section A

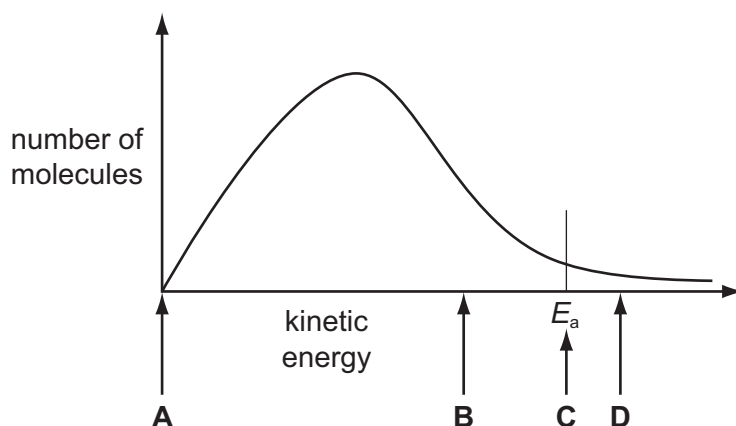
For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 The diagram below represents, for a given temperature, the Boltzmann distribution of the kinetic energy of the molecules in a mixture of two gases that react slowly together.

The activation energy for the reaction, E_a , is marked.

When the reaction is catalysed, the rate of reaction increases a little.

What will be the position of E_a for the catalysed reaction?



- 2 *Use of the Data Booklet is relevant to this question.*

In some types of spectroscopy, it is important to know if ions are isoelectronic. This means that they contain equal numbers of electrons.

Which ion is **not** isoelectronic with K^+ ?

- A** Ca^{2+} **B** Cl^- **C** S^{2-} **D** Ti^{3+}

- 3 Which row shows properties of a ceramic material?

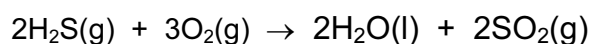
	melting point /K	boiling point /K	conductivity of solid
A	156	352	none
B	922	1380	good
C	2130	2943	good
D	3125	3873	none

- 4 Impure copper is purified by electrolysis. The electrolyte used in this process is aqueous copper(II) sulfate.

Which reaction takes place at the anode?

- A $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^{-}$
 B $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Cu(s)}$
 C $2\text{OH}^{-}(\text{aq}) \rightarrow \frac{1}{2}\text{O}_2(\text{g}) + \text{H}_2\text{O(l)} + 2\text{e}^{-}$
 D $2\text{H}_2\text{O(l)} + 2\text{e}^{-} \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^{-}(\text{aq})$

- 5 Hydrogen sulfide, H_2S , is released from volcanoes. It reacts with oxygen in the air to form sulfur dioxide.



$$\Delta H_f^\circ [\text{H}_2\text{S(g)}] = -21 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ [\text{H}_2\text{O(l)}] = -286 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ [\text{SO}_2(\text{g})] = -297 \text{ kJ mol}^{-1}$$

What is the standard enthalpy change of this reaction?

- A $-1208 \text{ kJ mol}^{-1}$
 B $-1124 \text{ kJ mol}^{-1}$
 C -562 kJ mol^{-1}
 D -541 kJ mol^{-1}

- 6 *Use of the Data Booklet is relevant to this question.*

In some countries, anhydrous calcium chloride is used as a drying agent to reduce dampness in houses. The anhydrous salt absorbs enough water to form the dihydrate $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$.

What is the percentage increase in mass?

- A 14% B 24% C 32% D 36%

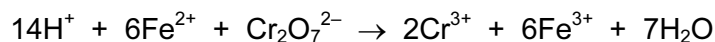
- 7 Copper and iodine are both shiny crystalline solids.

Which forces exist between particles in solid copper and between neighbouring iodine molecules in solid iodine?

	copper	iodine
A	ionic bonds	covalent bonds
B	ionic bonds	van der Waals' forces
C	metallic bonds	covalent bonds
D	metallic bonds	van der Waals' forces

- 8 *Use of the Data Booklet is relevant to this question.*

Ferrochrome is an alloy of iron and chromium. Ferrochrome can be dissolved in dilute sulfuric acid to produce a mixture of FeSO_4 and $\text{Cr}_2(\text{SO}_4)_3$. The FeSO_4 reacts with $\text{K}_2\text{Cr}_2\text{O}_7$ in acid solution according to the following equation.



When 1.00 g of ferrochrome is dissolved in dilute sulfuric acid, and the resulting solution titrated, 13.1 cm^3 of 0.100 mol dm^{-3} $\text{K}_2\text{Cr}_2\text{O}_7$ is required for complete reaction.

What is the percentage by mass of Fe in the sample of ferrochrome?

- A** 1.22 **B** 4.39 **C** 12.2 **D** 43.9

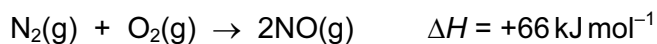
- 9 *Use of the Data Booklet is relevant to this question.*

When an evacuated glass tube of volume 200 cm^3 is filled with a gas at 300 K and 101 kPa, the mass of the tube increases by 1.06 g.

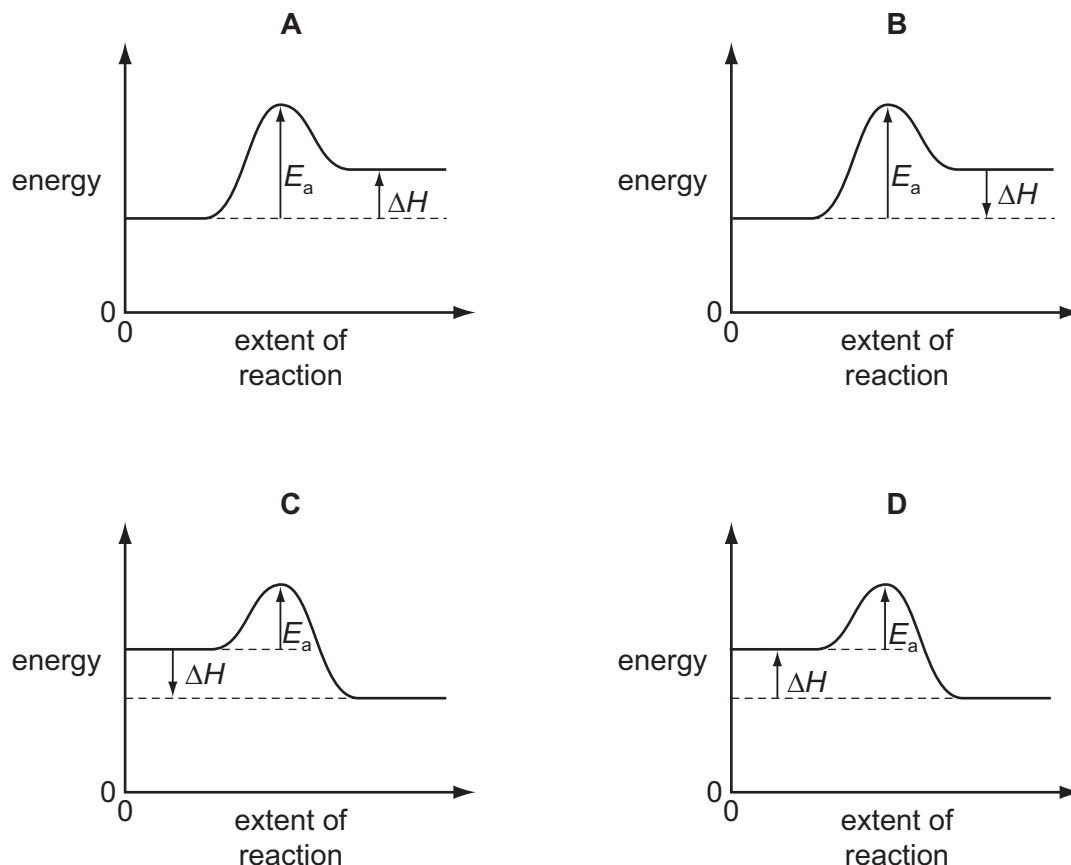
What is the identity of the gas?

- A** argon
B krypton
C neon
D xenon

- 10 Nitrogen monoxide is an atmospheric pollutant that is formed inside car engines by an endothermic reaction between nitrogen and oxygen.



Which labelled diagram correctly represents the energy profile for this reaction?



- 11 Use of the Data Booklet is relevant to this question.

When 0.47 g of a hydrocarbon was completely burnt in air, the energy released heated 200 g of water from 23.7 °C to 41.0 °C.

What was the amount of energy absorbed by the water?

- A $0.47 \times 4.18 \times 17.3 \text{ J}$
 B $0.47 \times 4.18 \times (273 + 17.3) \text{ J}$
 C $200 \times 4.18 \times 17.3 \text{ J}$
 D $200 \times 4.18 \times (273 + 17.3) \text{ J}$

12 What is the **ionic** equation for the reaction between aqueous sodium carbonate and dilute nitric acid?

- A** $2\text{HNO}_3(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g}) + 2\text{NO}_3^-(\text{aq})$
- B** $2\text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
- C** $2\text{HNO}_3(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \rightarrow 2\text{NaNO}_3(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
- D** $2\text{HNO}_2(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g}) + 2\text{NO}_2^-(\text{aq})$

13 Pieces of calcium and magnesium are reacted separately with cold water.

Pieces of calcium and magnesium are also burned separately with oxygen.

Which row correctly describes the observations from these reactions?

	calcium with cold water	magnesium with cold water	calcium with oxygen	magnesium with oxygen
A	rapid bubbling	slow bubbling	red flame	white flame
B	rapid bubbling	slow bubbling	white flame	red flame
C	slow bubbling	rapid bubbling	red flame	white flame
D	slow bubbling	rapid bubbling	white flame	red flame

14 **X**, **Y** and **Z** are compounds of three elements in Period 3. Their electrical conductivities are shown in the table.

	X	Y	Z
conductivity of the compound in the molten state	good	does not conduct	does not conduct
conductivity of the mixture obtained by adding the compound to water	good	good	does not conduct

What could be compounds **X**, **Y** and **Z**?

	X	Y	Z
A	Al_2O_3	SiCl_4	NaF
B	NaF	Al_2O_3	SiCl_4
C	NaF	SiCl_4	SiO_2
D	SiCl_4	Al_2O_3	SiO_2

- 15** A powder is known to be either a single sodium halide or a mixture of two sodium halides. A sample of the powder was dissolved in water. Aqueous silver nitrate was added, and a pale yellow precipitate was formed. When concentrated aqueous ammonia was added, the precipitate partly dissolved leaving a darker yellow precipitate.

What might the powder have consisted of?

- A** sodium bromide only
- B** sodium iodide only
- C** a mixture of sodium chloride and sodium bromide
- D** a mixture of sodium chloride and sodium iodide

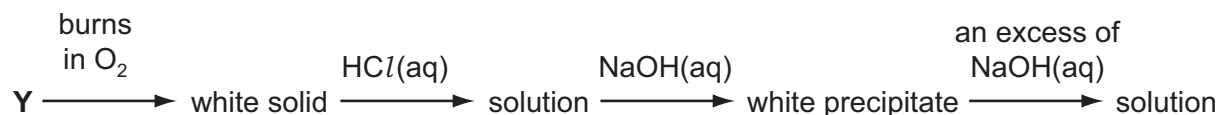
- 16** **X** is a mixture of two compounds of Group II elements.

X can undergo thermal decomposition to produce a white solid and only two gaseous products. One of the gaseous products relights a glowing splint.

What could be the components of mixture **X**?

- A** MgCl_2 and CaCO_3
- B** MgCO_3 and $\text{Ca}(\text{NO}_3)_2$
- C** $\text{Mg}(\text{NO}_3)_2$ and $\text{Ca}(\text{NO}_3)_2$
- D** MgO and CaSO_4

- 17** An element **Y** reacts according to the following sequence.



What could be element **Y**?

- A** Al
- B** Ca
- C** Mg
- D** P

- 18** One molecule of the oxide of element **Z** reacts with six molecules of water to produce an acidic compound.

What is element **Z**?

- A** aluminium
- B** phosphorus
- C** sodium
- D** sulfur

- 19 A student examines two semi-precious stones; one is agate, SiO_2 , and the other is calcite, CaCO_3 .

How could they be distinguished?

- A Add a fixed amount of cold aqueous sodium hydroxide to each separately and measure any temperature change.
- B Heat each separately over a gentle Bunsen flame and note which one melts first.
- C Shake each separately with dilute hydrochloric acid and test any gas formed.
- D Shake each separately with distilled water and add a few drops of Universal Indicator.

- 20 In this question, structural isomerism **and** stereoisomerism should be considered.

How many isomeric aldehydes have the formula $\text{C}_5\text{H}_{10}\text{O}$?

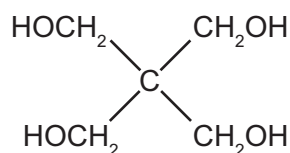
- A 3 B 4 C 5 D 6

- 21 Aldehydes and ketones are carbonyl compounds.

Which of them react with **both** LiAlH_4 and Tollens' reagent?

- A aldehydes only
- B both aldehydes and ketones
- C ketones only
- D neither aldehydes nor ketones

- 22 Pentaerythritol is used as an intermediate in the manufacture of paint.



pentaerythritol

Which statement about pentaerythritol is correct?

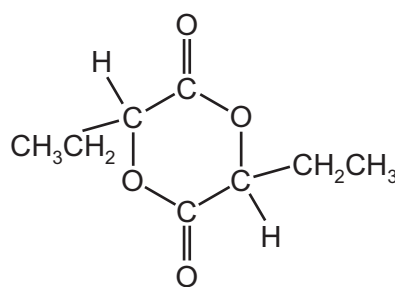
- A It can be dehydrated by concentrated sulfuric acid to form an alkene.
- B Its empirical formula and its molecular formula are different.
- C It does not react with acidified potassium manganate(VII).
- D One mole of it gives two moles of hydrogen gas on reaction with an excess of sodium.

- 23 A compound **Y**, C_4H_9Br , undergoes hydrolysis in aqueous alkali to form an alcohol, C_4H_9OH . The rate of this reaction is found to be unaffected by changes in the concentration of OH^- ions present.

Which is the most likely molecular structure of **Y**?

- A $CH_3CH_2CH_2CH_2Br$
- B $CH_3CH_2CHBrCH_3$
- C $(CH_3)_2CHCH_2Br$
- D $(CH_3)_3CBr$

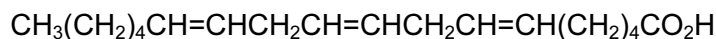
- 24 Compound **X** can be made from 2-hydroxybutanoic acid.



compound **X**

What should be heated with 2-hydroxybutanoic acid in order to make compound **X**?

- A acidified potassium dichromate(VI)
 - B aluminium oxide
 - C concentrated sulfuric acid
 - D dilute sodium hydroxide
- 25 The compound known as 'gamma-linolenic acid' is found in the seeds of the evening primrose plant.



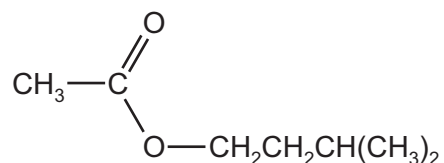
gamma-linolenic acid

How many *cis-trans* isomers are there with this structural formula?

- A 3
- B 6
- C 8
- D 12

- 26 Pheromones are used by insects and other animals as a means of communication.

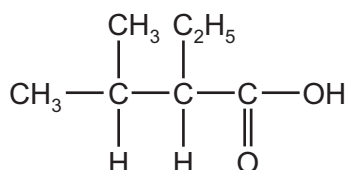
The pheromone in a bee sting is 3-methylbutyl ethanoate.



3-methylbutyl ethanoate

What are the organic products when 3-methylbutyl ethanoate is heated under reflux with aqueous sodium hydroxide?

- A $\text{CH}_3\text{CO}_2\text{H}$ and $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{OH}$
 B $\text{CH}_3\text{CO}_2\text{H}$ and $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{O}^-\text{Na}^+$
 C $\text{CH}_3\text{CO}_2^-\text{Na}^+$ and $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{OH}$
 D $\text{CH}_3\text{CO}_2^-\text{Na}^+$ and $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{O}^-\text{Na}^+$
- 27 The compound 2-ethyl-3-methylbutanoic acid is used as a flavouring in some food.



2-ethyl-3-methylbutanoic acid

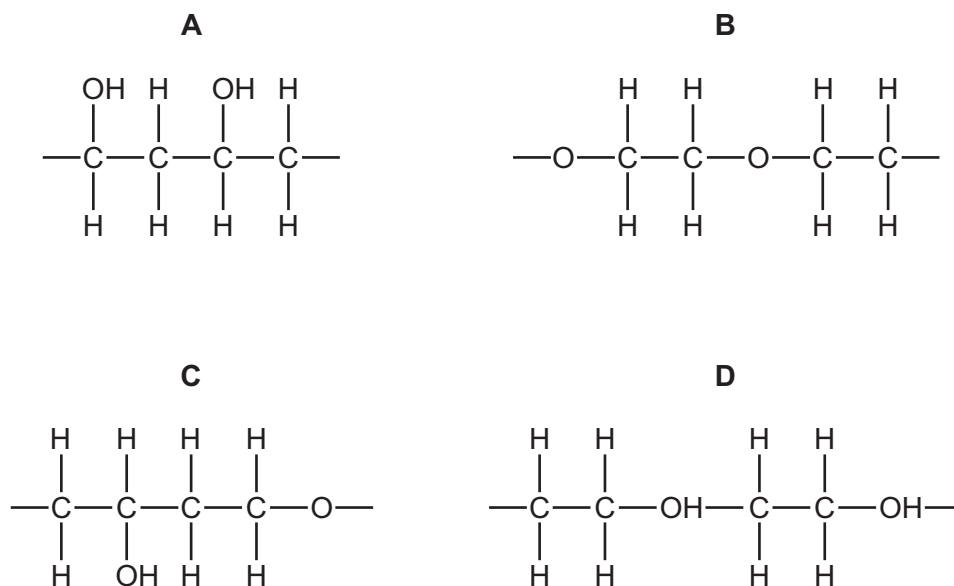
Which compound will produce 2-ethyl-3-methylbutanoic acid when heated under reflux with sodium cyanide in ethanol, followed by acid hydrolysis of the reaction product?

- A $\begin{array}{c} \text{CH}_3 \\ | \\ \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CHBr} - \text{CH}_3 \end{array}$
 B $\begin{array}{c} \text{CH}_3 \\ | \\ \text{CH}_3 - \text{CH} - \text{CHBr} - \text{CH}_2 - \text{CH}_3 \end{array}$
 C $\begin{array}{c} \text{CH}_3 \quad \text{C}_2\text{H}_5 \\ | \quad | \\ \text{CH}_3 - \text{CH} - \text{CH} - \text{CH}_2\text{Br} \end{array}$
 D $\begin{array}{c} \text{CH}_3 \quad \text{CH}_2\text{Br} \\ | \quad | \\ \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CH} - \text{CH}_3 \end{array}$

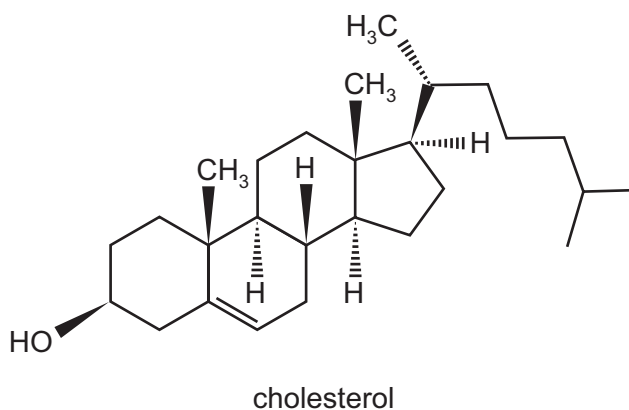
- 28 Poly(ethenol) can be used to make plastic bags that dissolve in water.

It may be considered to be made by addition polymerisation of $\text{CH}_2=\text{CH}(\text{OH})$.

Which structure represents a length of the polymer chain consisting of two monomer residues?



- 29 The diagram shows the structure of the naturally-occurring molecule cholesterol.



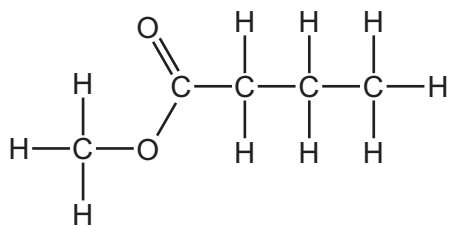
Student X stated that the seventeen carbon atoms in the four rings all lie in the same plane.

Student Y stated that this molecule displays *cis-trans* isomerism at the $\text{C}=\text{C}$ double bond.

Which of the students are correct?

- A** both X and Y
B neither X nor Y
C X only
D Y only

- 30 Methyl butanoate, $\text{C}_5\text{H}_{10}\text{O}_2$, is an ester used in the food industry to give products the flavour of apples.



methyl butanoate

Including methyl butanoate, how many **structural** isomers are there of $\text{C}_5\text{H}_{10}\text{O}_2$ that are esters?

- A** 6 **B** 8 **C** 9 **D** 10

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

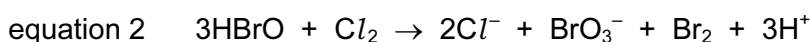
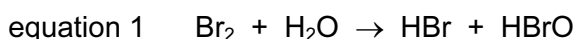
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

- 31** In a solution that contains both Br_2 and Cl_2 , a process takes place that produces BrO_3^- ions.

The process is represented by the following equations.



Which statements about these reactions are correct?

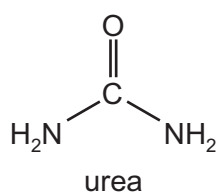
- 1** Chlorine is reduced in equation 2.
 - 2** Bromine is oxidised in both equation 1 and equation 2.
 - 3** Bromine is reduced in both equation 1 and equation 2.
- 32** Which statements are correct when referring to the isotopes of a single element?
- 1** The isotopes have different masses.
 - 2** The isotopes have different numbers of nucleons.
 - 3** The isotopes have different chemical reactions.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

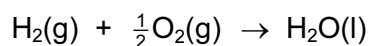
No other combination of statements is used as a correct response.

33 Which types of intermolecular forces can exist between adjacent urea molecules?



- 1** hydrogen bonding
- 2** permanent dipole-dipole forces
- 3** instantaneous dipole-induced dipole forces

34 Which names can be applied to the enthalpy change of the reaction shown?



- 1** enthalpy change of formation
- 2** enthalpy change of combustion
- 3** enthalpy change of hydration

35 Compared with the HI molecule, the bond P..... of the HBr molecule is Q.....

Which pairs of words correctly complete the above sentence?

	P	Q
1	energy	greater
2	length	less
3	polarity	greater

36 Element **X** is a solid. It is found in some fuels.

Its oxide **Y** is formed in car engines. **Y** is acidic.

Further oxidation of **Y** to **Z** can occur in the atmosphere.

Which statements about **Y** and **Z** are correct?

- 1 Molecule **Y** has lone pairs of electrons.
- 2 The atmospheric oxidation of **Y** to **Z** is a catalysed reaction.
- 3 **Y** is a colourless gas.

37 Which statements about the photochemical chlorination of ethane are correct?

- 1 A propagation step in the mechanism is $\text{C}_2\text{H}_5\cdot + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}\cdot$.
- 2 Butane is present in the products.
- 3 The initiation step is the heterolytic fission of chlorine.

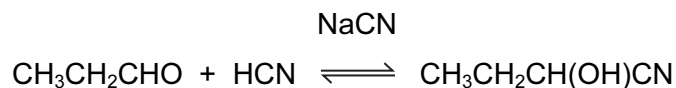
38 Which compounds produce pent-2-ene as either one of the products, or as the only product, on heating with potassium hydroxide in ethanol?

- 1 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$
- 2 $\text{CH}_3\text{CHBrCH}_2\text{CH}_2\text{CH}_3$
- 3 $\text{CH}_3\text{CH}_2\text{CHBrCH}_2\text{CH}_3$

39 Which reactions have a coloured organic product?

- 1 ethanal + 2,4-dinitrophenylhydrazine reagent
- 2 ethanol + acidified potassium dichromate(VI)
- 3 ethene + cold dilute acidified potassium manganate(VII)

40 Propanal will react with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.



Which statements about the reaction of propanal with hydrogen cyanide are correct?

- 1 The sodium cyanide provides a stronger nucleophile than HCN.
- 2 The reaction mechanism involves two steps.
- 3 The product of the reaction has a chiral carbon atom.

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